purchased from "green" sources?

- Why?/Why not?
- (For those who answered "yes"): How much would you be willing to pay extra?

D. Pricing options: NSTAR is considering a few different pricing options depending on the percentage of Green Power a customer elects to choose (ex. either 25%, 50% or 100% of their electricity would be "Green"). (Hand out pricing description.)

Incremental cost to monthly electricity bill (based on ave. monthly bill of $65-70?):

25% Green Power: $ 5.88
50% Green Power: $11.75
100% Green Power: $23.50

1. For each of the options above, how interested would you be in participating in such a program?
   - Very Interested, Somewhat Interested, Somewhat Uninterested, Not at all Interested (circle response on handout for each option)
   - Why?/Why not?
2. If NSTAR could only offer one or two of these options, which is most appealing/which should they offer? (First choice, second choice)
3. If NSTAR only offered one or two options (as just discussed), how interested would you be in participating in such a program?
   - Very Interested, Somewhat Interested, Somewhat Uninterested, Not at all Interested
   - Why?/Why not?

E. How would you prefer to determine how much you pay for Green Power each month? (Write options on easel.)

- Buy Green Power for the amount of electricity you actually use each month? (i.e., fixed percentage of total; dollar amount could vary)

OR:

- Pay a fixed dollar amount each month toward the purchase of Green Power? (i.e., regardless of monthly usage; percentage of Green Power would vary)

(Show of hands, which option is preferred. Discuss reasons for preference.)

F. The Commonwealth of Massachusetts plans to make available to Green Power buyers a deduction on their state tax return for the extra cost they pay for Green Power (would be a deduction off your income, like mortgage interest).

Would this state tax deduction make you be more inclined to purchase Green Power?

- By show of hands: Much more inclined, Somewhat more inclined, It wouldn't make a difference, Less inclined
- Why/why not?

G. There are different ways in which NSTAR could offer Green Power to their customers (write options on easel). For example:

- Consumers could pick the source or sources of power themselves (within the portion that is "green", consumers could dictate specific percentages, ex. 90% wind power and 10% solar power)

OR

- NSTAR could create a mix of Green Power sources that is the most cost effective

1. Which option would you prefer? (Show of hands) Why?
2. How important is it to you that you can pick the exact sources? Does that matter? Why?/Why not?

H. Going back to the various types or sources of Green Power we discussed previously, do you have a preference between various sources? First, on your own, rank them in order of preference, first choice to fourth (last) choice. Or, if you don't have a strong preference, just write "no preference". Then, by show of hands, discuss preferences as a group, where they apply:

- Wind power
- Solar power
- Plant/biomass
- Landfill gas

- Reasons for preferences?
- Are there any sources that you perceive negatively or would not want to purchase through such a program?

I. Like your telephone bill, where you can choose from different service providers, you can also choose different electricity providers. (By the way, how many were aware of this option?) By a show of hands, how many of you would prefer to purchase Green Power from the following (write choices on easel):

- NSTAR?
- An independent provider?
- Indifferent/doesn't matter

– Reasons for preference?

J. How important is it for you to know <u>exactly</u> where the Green Power is being produced—that is, exactly where the windmill, landfill, etc. is located)?

– (Show of hands): Very important, Somewhat important, Somewhat unimportant, Not at all important?

– Why/why not?

– If you didn't know where the power came from (what exact location), would you still participate? (show of hands: Very interested, somewhat interested, somewhat uninterested, not at all interested)

– Reactions to specific energy sources (current and proposed)—as time permits: (Awareness/perceptions of these potential sources? Would you be interested in participating in the program if Green Power came from these sources?)

  - windmill in Hull
  - MWRA plant on Deer Island (biomass, from waste water)
  - Landfill in Chicopee
  - Proposed windmills on Boston Harbor Islands (Specific probe: If NSTAR was associated with this project, how would it impact your impression of NSTAR? Positive/negative/neutral?)
  - Proposed wind farm off Cape Cod

K. On a scale of 1-10 (where 1 = not at all important and 10 = very important), how important is it for NSTAR's Green Power Program to be endorsed or supported by:

  - A leading environmental advocate? (Specific probes: Green Mountain Power/Energy (?); MASSPIRG?, Sierra Club?; Amory Lovins? – Familiar with any of these names? Whose endorsement would be compelling?)
  - Massachusetts state government?

L. Green Certificates:

1. Present Concept (Hand out concept. Read aloud.)

Green Power costs more to produce than conventional power, but it also provides environmental benefits. Therefore, it's possible to say that customers who purchase Green Power are really getting two things: the electricity needed to power their homes and the environmental benefits associated with this power. (This is similar to the way a customer who is willing to pay more for an organic apple is really paying for the apple and then paying extra for the environmental benefits such as decreased fertilizers and pesticides in the ground.)

The electricity generated from Green Power can be sold at that same price as conventional power in the wholesale market if the environmental attributes are separated out. "Green certificates" represent the extra cost to generate Green Power and the environmental benefits associated with Green Power.

In New England, a new accounting system was set up this year that uses "green certificates" to tell consumers where their electricity was generated. NSTAR would buy these certificates from renewable power generators to assure you that your power is now renewable.

2. Probes:

- What do you think of this idea? Is this appealing to you?
- How interested would you be in purchasing green certificates?
  - Very Interested, Somewhat Interested, Somewhat Uninterested, Not at all Interested
- Is it confusing to anyone? (If so, ask for show of hands)

3. {Note: If possible}: (Show mocked-up certificate and explain): NSTAR is considering a way to send its customers who participate in the Green Power option green certificates (similar to this one), which would indicate the green power a customer had purchased during the previous 3 months.

- How interested would you be in receiving actual paper "green certificates"?
  - Very Interested, Somewhat Interested, Somewhat Uninterested, Not at all Interested

M. How would it affect your attitude toward NSTAR as a company if NSTAR does offer a Green Power Program (show of hands)?

- Greatly improve it, Somewhat improve it, Make no change, Somewhat lower it, Greatly lower it
- Why? What does it tell you about NSTAR as a company if they do offer a Green Power Program?

V. **Wrap up**:

Any other questions, comments or suggestions? (from back room or from respondents)

THANK YOU VERY MUCH FOR PARTICIPATING IN OUR DISCUSSION!

Name:____Time: 6:00 or 8:00

Green Power

Green Power is typically described as electricity created from renewable energy sources that have a relatively low impact on the environment. Examples include wind energy, solar energy, energy generated from plant material such as wood chips, or gas recovered from closed landfills. Green Power sources are continuously and sustainably available in the environment and are non-polluting and emission-free.

Directions:

- Circle any words or phrases in the paragraph above that are particularly appealing. Cross out any words or phrases you find unappealing. Put a question mark next to any words or phrases that are confusing or difficult to understand.

- What is your top of mind impression of this idea?

  ____

  ____

  ____

  ____

- How favorable/unfavorable an impression do you have of the idea stated above? (circle one answer)

  Very Favorable

  Somewhat Favorable

  Somewhat Unfavorable

  Very Unfavorable

Name:____ **Time: 6:00** or **8:00**

Green Power Sources

Wind Energy

Wind Energy comes from moving air which is converted to electric power to create electricity. Due to the unequal solar heating of the earth, wind is generated. As air flows past the rotors of a wind turbine, the rotor spins and drives the shaft of an electric generator.

How favorable an impression do you have of Wind Energy? (circle one answer)

Very Favorable

Somewhat Favorable

Somewhat Unfavorable

Very Unfavorable

Solar Energy

Solar Electric or Photovoltaic Systems convert some of the energy in sunlight directly into electricity. Photovoltaic (PV) cells are made primarily of silicon, which when combined with one or more other materials, exhibits unique electrical properties in the presence of sunlight. Electrons are excited by the light and move through the silicon. This is known as the photovoltaic effect and results in direct current (DC) electricity.

How favorable an impression do you have of Solar Energy? (circle one answer)

Very Favorable

Somewhat Favorable

Somewhat Unfavorable

Very Unfavorable

Plant/Biomass

Biomass energy is available from organic materials in the environment. It includes energy available in wood, agricultural crops, crop residues, industrial and municipal organic waste, food processing waste and animal wastes. These wastes of various human and natural activities can be burned to create heat and/or steam that is used to generate electricity.

How favorable an impression do you have of Biomass Energy (or BioPower)? (circle one answer)

Very Favorable

Somewhat Favorable

Somewhat Unfavorable

Very Unfavorable

Landfill gas

Landfill gas is created when waste in a closed landfill decomposes under anaerobic (or oxygen free) conditions. Because landfill gas is about 50% methane, it can be used as a source of energy similar to natural gas (which is about 90% methane). Since landfill gas is generated continuously, it provides a reliable fuel for a range of energy applications, including heating and electric power generation.

How favorable an impression do you have of Landfill Gas Energy? (circle one answer)

Very Favorable

Somewhat Favorable

Somewhat Unfavorable

Very Unfavorable

Name:____Time: 6:00 or 8:00

NSTAR Green Power Option

NSTAR Electric is considering offering Green Power as an optional service. NSTAR would offer its customers the choice of electricity that is created by renewable sources, such as wind, solar, plant/biomass and landfill gas. By choosing this product, NSTAR customers would be able to increase the Green Power used to generate the electricity they use. In doing so, they will help the local environment by reducing emissions and reducing our dependence on natural resources.

Customers would begin purchasing Green Power by specifying an option on their electric bill. The Green purchase would begin on the following bill cycle. Choosing Green Power in no way changes the reliability or quality of a customer's electric service.

Directions:

- Circle any words or phrases that are particularly appealing. Cross out anything you find unappealing. Put a question mark next to any words or phrases that are confusing or difficult to understand.
- What is your top of mind impression of this idea?

  ____

  ____

  ____

  ____

- Based on what we've discussed so far, how interested would you be in participating in such a Green Power Program? (circle one answer)

  Very Interested

  Somewhat Interested

  Somewhat Uninterested

  Not at all interested

00109

Name:____ **Time: 6:00** or **8:00**

NSTAR Green Power Service
Pricing Options

Depending on the percentage of Green Power a customer elects to choose, the incremental cost of the Green Power would be as follows:

Incremental cost to monthly electricity bill (based on an average monthly bill of $65-70):

25% Green Power: $5.88	Very Interested Somewhat Uninterested	Somewhat Interested Not at all Interested
50% Green Power: $11.75	Very Interested Somewhat Uninterested	Somewhat Interested Not at all Interested
100% Green Power: $23.50	Very Interested Somewhat Uninterested	Somewhat Interested Not at all Interested

Directions:

- For each pricing option above, circle your level of interest in choosing that pricing option (circle one answer for each of the three pricing options).
- If NSTAR could only offer one or two options, which would be the most appealing (which should they offer)? Write 1st, 2nd choice above.

00110

Name:____ **Time: 6:00** or **8:00**

Endorsement of Green Power Program

1. On a scale of 1-10 (where 1 = not at all important and 10 = very important), how important is it for NSTAR's Green Power Program to be endorsed or supported by:

   - A leading environmental advocate? (circle one answer)

     1 2 3 4 5 6 7 8 9 10

   - Which of the following environmental advocates have you heard of? Whose endorsement (if any) would be compelling? (circle as many responses as apply)

Have heard of:	**Endorsement would be compelling**:
Green Mountain Power	Green Mountain Power
MASSPIRG	MASSPIRG
Sierra Club	Sierra Club
Amory Lovins	Amory Lovins

2. On a scale of 1-10 (where 1 = not at all important and 10 = very important), how important is it for NSTAR's Green Power Program to be endorsed or supported by:

   - Massachusetts state government? (circle one answer)

     1 2 3 4 5 6 7 8 9 10

"Green Certificates"

Green Power costs more to produce than conventional power, but it also provides environmental benefits. Therefore, it's possible to say that customers who purchase Green Power are really getting two things: the electricity needed to power their homes and the environmental benefits associated with this power. (This is similar to the way a customer who is willing to pay more for an organic apple is really paying for the apple and then paying extra for the environmental benefits such as decreased fertilizers and pesticides in the ground.)

The electricity generated from Green Power can be sold at that same price as conventional power in the wholesale market if the environmental attributes are separated out. "Green certificates" represent the extra cost to generate Green Power and the environmental benefits associated with Green Power.

In New England, a new accounting system was set up this year that uses "green certificates" to tell consumers where their electricity was generated. NSTAR would buy these certificates from renewable power generators to assure you that your power is now renewable.

From:	**"Gundal, Frank" <Frank_Gundal@nstaronline.com>**
To:	**"Angley, Ellen" <Ellen_Angley@nstaronline.com>, "Barsamian, Peter" <Peter_Barsamian@nstaronline.com>, "Chiara, Stephen" <Stephen_Chiara@nstaronline.com>, "Conner, Penelope" <Penelope_Conner@nstaronline.com>, "Cunningham, Gary" <Gary_Cunningham@nstaronline.com>, "Lyford, Richard" <Richard_Lyford@nstaronline.com>, "Martin, Robert" <Robert_Martin@nstaronline.com>, "Milton, John" <John_Milton@nstaronline.com>, "Razzaboni, James" <James_Razzaboni@nstaronline.com>, "Reed, Mark" <Mark_Reed@nstaronline.com>, "Thompson, George" <George_Thompson@nstaronline.com>**
Subject:	**FW: GREENUP SERVICE FILING APPROVED!**
Date sent:	**Wed, 16 Jul 2003 08:36:03 -0500**

FYI

Also, I have gotten a couple of emails from the MTC pushing us to have a program available by 1/1/04 otherwise the tax write off will not be available for 2004.

FG

-----Original Message-----
From: Lee, Judy Y. [mailto:JUDY.Y.LEE@us.ngrid.com]
Sent: Monday, July 14, 2003 5:08 PM
To: tom.rawls@greenmountain.com; amy.mcginty@newwindenergy.com; aoconnor@aimnet.org; ahouston@apx.com; Barry Perlmutter; btrevillion@sterlingplanet.com; brent.alderfer@newwindenergy.com; bkeane@smartpower.org; charak@nclc.org; Christopher Frangione; erich@ripower.org; frank_gundal@nstaronline.com; gpetlin@resource-solutions.org; jkopke@massenergy.com; Jeff Keeler; Jennifer.lange@csgrp.com; moskal.john@epamail.epa.gov; karen.oneill@greenmountain.com; Keri Bolding; Kristen.Costello@constellation.com; lhoke@MIPandL.org; Larry@massenergy.com; laurad@cetonline.org; lhicks@kema-xenergy.com; lbenander@cooplife.com; Martha Broad; Matt DeLuca; mmorais@sel.com; mjones@sterlingplanet.com; Meredith.Miller@constellation.com; tennis25@rcn.com; ngreene@nrdc.org; nicole@massenergy.com; pat.stanton@csgrp.com; energyhome@yahoo.com; rich.travaglini@greenmountain.com; bgrace@seadvantage.com; Robert A. Maddox, Jr.; rogborg@aol.com; rmitchell@sterlingplanet.com; swoodhouse@kema-xenergy.com; Steve Cowell; sbmacausland@earthlink.net; Robert Sydney (E-mail); Alan Wilson Esq. (E-mail); Deanna L. Ruffer; Fran Cummings (E-mail); George B. Dean; Gerry.Bingham@state.ma.us; Jason Gifford; Judy Silvia (E-mail); Karlynn Cory; Matthew L. Schemmel; Paul Gromer (E-mail); Philip F. Holahan (E-mail); Raphael Herz (E-mail); Rob Pratt (E-mail); Yetman, Kathleen; Arons, Pam A.; Burns, Theresa M.; Dowling, Colleen; Drew, Deborah; Hager, Michael; Rabinowitz, Amy G.; Robinson, Thomas G.
Subject: GREENUP SERVICE FILING APPROVED!
Importance: High

Dear All,

Great news! We received word from the DTE today that our filing was approved. The formal order will be circulated as soon as it is available. Thank you for all your time and effort throughout this process. We look forward to working together to make the program a success.

Regards,
Judy

Please make sure you are familiar with the NSTAR Information Systems Acceptable Use Policy.

00114

From:	"Gundal, Frank" <Frank_Gundal@nstaronline.com>
To:	"Connelly, Paul" <Paul_Connelly@nstaronline.com>, "Lehman, Dena" <Dena_Lehman@nstaronline.com>, "Angley, Ellen" <Ellen_Angley@nstaronline.com>, "Barsamian, Peter" <Peter_Barsamian@nstaronline.com>, "Chiara, Stephen" <Stephen_Chiara@nstaronline.com>, "Conner, Penelope" <Penelope_Conner@nstaronline.com>, "Cunningham, Gary" <Gary_Cunningham@nstaronline.com>, "Lyford, Richard" <Richard_Lyford@nstaronline.com>, "Martin, Robert" <Robert_Martin@nstaronline.com>, "Milton, John" <John_Milton@nstaronline.com>, "Razzaboni, James" <James_Razzaboni@nstaronline.com>, "Reed, Mark" <Mark_Reed@nstaronline.com>, "Thompson, George" <George_Thompson@nstaronline.com>
Copies to:	"'lhicks@kema-xenergy.com'" <lhicks@kema-xenergy.com>, "'gifford@masstech.org'" <gifford@masstech.org>
Subject:	FW: Directions to Focus on Boston/Waltham & other logistics
Date sent:	Mon, 14 Jul 2003 13:30:57 -0500

Folks,

Please RSVP if you would like to attend. This is for 7/22 6:00 pm to ~10:00 pm.

Frank

-----Original Message-----
From: Lisa Brown [mailto:lbrownma@comcast.net]
Sent: Monday, July 14, 2003 10:38 AM
To: 'Gundal, Frank'
Subject: Directions to Focus on Boston/Waltham & other logistics

Frank,

Attached are directions to the facility. Please let me know the list of attendees. Also, please let me know whether you want to pre-order a meal for the back room (for dinner) or whether you want to just order from the menus when you're there. Also, please ask any NSTAR people that when they arrive for the groups to just say they are there "to observe the groups" instead of announcing that they're from NSTAR. (They will be escorted to the back room.) Even though we haven't made the study "blind", I still think it's better to keep it somewhat "quiet" in front of respondents.

Thanks!

Lisa

-----Original Message-----
From: Gundal, Frank [mailto:Frank_Gundal@nstaronline.com]
Sent: Monday, July 14, 2003 8:55 AM
To: 'Lisa Brown'
Subject: RE: Revised Discussion guide and respondent handouts

Do you have directions to the focus group?

> -----Original Message-----
> **From:** Lisa Brown [mailto:lbrownma@comcast.net]
> **Sent:** Monday, July 14, 2003 9:43 AM
> **To:** 'Gundal, Frank'
> **Cc:** peter_barsamian@nstaronline.com
> **Subject:** Revised Discussion guide and respondent handouts
>
> Hello!

00115

I hope you each had a nice vacation. Attached you'll find the revised discussion guide for the focus groups next week. I've also printed up the respondent handouts (what the participants will be given to read and any written questions they'll be given)--the second file attached. Please note the following on the discussion guide:

- I changed the order a bit from the previous version of the discussion guide. Specifically, I moved any questions regarding pricing further forward, just after the initial presentation of NSTAR's Green Power concept. The concept seemed to beg the question "how much does it cost?", so it made sense to get to that issue sooner. As you'll see, I still ask for respondents' impressions of the concept before I present the pricing options, however. I think the overall order seems to flow better now, but let me know if you have any questions.

- Additions: I expanded the pricing section to discuss the 3 pricing options, as we discussed. Also, I found a good "consumer friendly" explanation of the green certificates in that International Green Power Report you sent. Please review and let me know if it looks OK. Frank, also please let me know if you want to present a "mock" green certificate. I've included that in the guide in case you do.

- Timing: The guide is running about 15 minutes too long, given the expanded pricing section (with the multiple pricing options) and the expanded green certificate section. Also, the addition of the probes of specific green power sources (ex. wind farm off Cape Cod, proposed windmills on Boston Harbor Island, etc.) could easily add 15 minutes. Please review the guide and let's discuss how to prioritize. If there are any "would be nice to know., but secondary" questions, please let me know. (By the way, I can take you through how I timed each section if you'd like to see how it's timing--i.e, how I'm timing at 2 1/4 hours.)

- A few remaining questions:

 - I need confirmation of the average monthly bill for the pricing section (we had discussed $65-70, but is that confirmed?)
 - On the environmental advocate section, is it "Green Mountain Power" or "Green Mountain Energy"?

Finally, you'll note on the handouts that I shortened the definitions slightly for the Green Power sources (pages 2-3 of the handouts). I cut a bit out in order to make them a bit more consumer friendly and in the interest of time. Please take a look and make sure you're OK with them as they read. Thanks. (I also streamlined the questions in this section, to get to the NSTAR concept sooner.)

Let's discuss at your convenience.

Thanks,

Lisa

Lisa C. Brown
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Medfield, MA 02052
phone: (508) 359-1069
fax: (508) 359-1065
email: lbrownma@attbi.com

00116

00117

FOCUS ON BOSTON

A Focus Group & Video Conference Center

Focus on Boston
75 Third Avenue
Waltham, MA 02451

From I-90 (Mass Pike):

Head West on I-90.
Bear right on ramp at sign reading "**Exit 15 I-95 N/I-95 S to Weston**" and go North for 1.0 miles.
Continue on I-95, Rt 128 and go North for 4 miles.
Bear right on ramp at sign reading "**Exit 27A Totten Pond Road to Waltham**" and go Northeast for .2 miles
Turn right on Third Avenue.
Focus on Boston will be on your right at 75 Third Avenue
in the offices/retail space across from the Westin Hotel.

From I-95:

Bear right on ramp at sign reading "**Exit 27A Totten Pond Road to Waltham**" and go Northeast for .2 miles
Turn right on Third Avenue.
Focus on Boston will be on your right at 75 Third Avenue
in the offices/retail space across from the Westin Hotel.

From Logan Airport:

Take I-93 south (towards Boston).
Take exit 20 (Mass Pike-West)
Head West on I-90.
Bear right on ramp at sign reading "**Exit 15 I-95 N/I-95 S to Weston**" and go North for 1.0 miles.
Continue on I-95, Rt 128 and go North for 4 miles.
Bear right on ramp at sign reading "**Exit 27A Totten Pond Road to Waltham**" and go Northeast for .2 miles
Turn right on Third Avenue.
Focus on Boston will be on your right at 75 Third Avenue
in the offices/retail space across from the Westin Hotel.

ph#(617) 946-0755 WWW.FocusOnBoston.com fx#(617)946-0850

From:	**"Cunningham, Gary" <Gary_Cunningham@nstaronline.com>**
To:	**"Gundal, Frank" <Frank_Gundal@nstaronline.com>**
Subject:	**RE: Next steps**
Date sent:	**Thu, 3 Jul 2003 08:12:21 -0500**

Frank:

I would think "Green Certificates" might be easier to comprehend, especially if we are considering actually issuing "Certificates"

-----Original Message-----
From: Gundal, Frank
Sent: Thursday, July 03, 2003 9:10 AM
To: Cunningham, Gary
Subject: FW: Next steps

Gary,

What do you suggest, Green Tags or Green Certificates?

FG

-----Original Message-----
From: Lisa Brown [mailto:lbrownma@comcast.net]
Sent: Wednesday, July 02, 2003 9:45 PM
To: 'Gundal, Frank'
Subject: Next steps

Frank:

I enjoyed meeting with you all today and felt like it was a very productive meeting. In terms of next steps, I'll be working on revising the discussion guide next week while you're out. One additional thought since our meeting: as far as involving KEMA/XENERGY (besides you sending them the revised discussion guide once I send it to you), would it also make sense to ask them if they have come across a "consumer friendly" explanation of the green tag concept? Maybe they might have something to suggest in that area. Just a thought...If not, I'll work on something and will run it by you when you return. Also, which term would you like to use in the groups: "green tags" or "green certificates"?

As far as the commercial customer project, I'll look for your email with further input when I return next week. As I think I mentioned, I am leaving Thurs AM (7/3) for the Cape. If I have any questions on what you send me, whom should I call to follow up on that project while you're out? (Would it also be Jim Razzaboni?) I'm planning to put a proposal together at the beginning of next week and may have some questions.

Have a great vacation!

Lisa

Lisa C. Brown
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phone: (508) 359-1069
fax: (508) 359-1065
email: lbrownma@attbi.com

00119

Please make sure you are familiar with the NSTAR Information Systems Acceptable Use Policy.

00120

From:	**"Gundal, Frank" <Frank_Gundal@nstaronline.com>**
To:	**"Cunningham, Gary" <Gary_Cunningham@nstaronline.com>**
Subject:	**FW: Next steps**
Date sent:	**Thu, 3 Jul 2003 08:09:59 -0500**

Gary,

What do you suggest, Green Tags or Green Certificates?

FG

-----Original Message-----
From: Lisa Brown [mailto:lbrownma@comcast.net]
Sent: Wednesday, July 02, 2003 9:45 PM
To: 'Gundal, Frank'
Subject: Next steps

Frank:

I enjoyed meeting with you all today and felt like it was a very productive meeting. In terms of next steps, I'll be working on revising the discussion guide next week while you're out. One additional thought since our meeting: as far as involving KEMA/XENERGY (besides you sending them the revised discussion guide once I send it to you), would it also make sense to ask them if they have come across a "consumer friendly" explanation of the green tag concept? Maybe they might have something to suggest in that area. Just a thought...If not, I'll work on something and will run it by you when you return. Also, which term would you like to use in the groups: "green tags" or "green certificates"?

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Have a great vacation!

Lisa

Lisa C. Brown
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21 Tubwreck Drive
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phone: (508) 359-1069
fax: (508) 359-1065
email: lbrownma@attbi.com

00121

From:	"Conner, Penelope" <Penelope_Conner@nstaronline.com>
To:	"Cunningham, Gary" <Gary_Cunningham@nstaronline.com>, "Gundal, Frank" <Frank_Gundal@nstaronline.com>, "Barsamian, Peter" <Peter_Barsamian@nstaronline.com>, "Martin, Robert" <Robert_Martin@nstaronline.com>
Copies to:	"Angley, Ellen" <Ellen_Angley@nstaronline.com>
Subject:	RE: Green Power Pricing estimates
Date sent:	Thu, 3 Jul 2003 07:44:44 -0500

Gary, this is great information. I am very pleasantly surprised at the cost. I feared higher costs. Thank you so much.

Penni

-----Original Message-----
From: Cunningham, Gary
Sent: Wednesday, July 02, 2003 9:40 AM
To: Gundal, Frank; Barsamian, Peter; Martin, Robert
Cc: Angley, Ellen; Conner, Penelope
Subject: Green Power Pricing estimates

Frank:

Here is what I came up with for a VERY ROUGH estimate on Green Pricing:

Effect on average (500kWh) Customer

100%	$ 23.50
50%	$ 11.75
25%	$ 5.88

Dark Green, since it is not specifically defined in Massachusetts (or anywhere that I have been able to find) was very hard to price.

Given the very tight market in Massachusetts for Renewable Energy certificates in 2004, the fact that the overwhelming majority of the qualifying Mass Renewable generators are NOT "Dark Green" by any stretch, and NSTAR's requirement that the Green Power be a bundled product, you should plan on AT LEAST an additional 50% premium for "Dark Green", and that is if we could even find it!

Hope this helps

Gary Ph: 781-441-8059
Fx: 781-441-8066

00122

From:	**"Cunningham, Gary" <Gary_Cunningham@nstaronline.com>**
To:	**"Gundal, Frank" <Frank_Gundal@nstaronline.com>, "Barsamian, Peter" <Peter_Barsamian@nstaronline.com>, "Martin, Robert" <Robert_Martin@nstaronline.com>**
Copies to:	**"Angley, Ellen" <Ellen_Angley@nstaronline.com>, "Conner, Penelope" <Penelope_Conner@nstaronline.com>**
Subject:	**Green Power Pricing estimates**
Date sent:	**Wed, 2 Jul 2003 08:39:55 -0500**

Frank:

Here is what I came up with for a VERY ROUGH estimate on Green Pricing:

Effect on average (500kWh) Customer

100%	$ 23.50
50%	$ 11.75
25%	$ 5.88

Dark Green, since it is not specifically defined in Massachusetts (or anywhere that I have been able to find) was very hard to price.

Given the very tight market in Massachusetts for Renewable Energy certificates in 2004, the fact that the overwhelming majority of the qualifying Mass Renewable generators are NOT "Dark Green" by any stretch, and NSTAR's requirement that the Green Power be a bundled product, you should plan on AT LEAST an additional 50% premium for "Dark Green", and that is if we could even find it!

Hope this helps

Gary Ph: 781-441-8059
Fx: 781-441-8066

00123

From:	"Gundal, Frank" <Frank_Gundal@nstaronline.com>
To:	"Angley, Ellen" <Ellen_Angley@nstaronline.com>, "Barsamian, Peter" <Peter_Barsamian@nstaronline.com>, "Chiara, Stephen" <Stephen_Chiara@nstaronline.com>, "Conner, Penelope" <Penelope_Conner@nstaronline.com>, "Cunningham, Gary" <Gary_Cunningham@nstaronline.com>, "Lyford, Richard" <Richard_Lyford@nstaronline.com>, "Martin, Robert" <Robert_Martin@nstaronline.com>, "Milton, John" <John_Milton@nstaronline.com>, "Razzaboni, James" <James_Razzaboni@nstaronline.com>, "Reed, Mark" <Mark_Reed@nstaronline.com>, "Thompson, George" <George_Thompson@nstaronline.com>
Subject:	FW: International Green Power report - pdf file
Date sent:	Tue, 1 Jul 2003 12:56:52 -0500

Folks,

Customer Care purchased the following report, it should provide us some good background information to assist us in our efforts.

Gary - Thanks for the tip.

FG

-----Original Message-----
From: Zimmerman, Elaine
Sent: Monday, June 30, 2003 3:31 PM
To: Gundal, Frank
Subject: FW: International Green Power report - pdf file

Frank

This is the document that you asked me to order for you.

Elaine
-----Original Message-----
From: Energy Info Source Mailbox [mailto:eismail@energyinfosource.com]
Sent: Monday, June 30, 2003 3:21 PM
To: elaine_zimmerman@nstaronline.com
Subject: International Green Power report - pdf file

Attached is your International Green Power report from Energy Info Source. Viewing the report requires Adobe Acrobat Reader 4.0 or higher, available free at: http://www.adobe.com/products/acrobat/readstep2.html If you have any problems with the attachment or any questions, please feel free to contact us at custsvc@energyinfosource.com or 888-986-2250

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Energy Info Source
Your World of Energy

International Green Power Report

October 2002

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Executive Summary

At this very moment, the world's largest offshore wind farm is being being built off the east coast of Ireland. At the same time, an isolated village in the Phillipines is being powered by solar energy. Meanwhile, miles below the surface of the earth, hot magma is boiling water to generate electricity in California.

These are just three examples of how green power -- power generation technologies that have a relatively low impact on the environment -- is changing the way energy is generated all over the world. Green power sources, such as the three mentioned above, are continuously and sustainably available in the environment. They are non-polluting, emission free, and the waste, if there is any, can also often be used as a fuel source. In keeping with general industry consensus, this report focuses on bio, geothermal, ocean, solar, and wind power as green energy sources. Hydro power is generally not considered to be green because of the environmental damage done by large-scale dams. However, this view is slowly changing with the introduction of small-scale run-of-river plants, that have a minimal environmental impact. In addition, fuel cells and stirling engines are not green in and of themselves, but may be green depending on how they are fueled.

All energy resources have particular strengths and weaknesses and different histories of public policy support. Conventional energy sources such as coal, oil, natural gas, nuclear power, and hydroelectric power, are mature industries that have played a vital role in establishing the present strength of the many countries' economic well being. They have all benefited from a wide range of critically important public policy support. Although conventional energy sources continue to deliver impressive technological and operational improvements, well-documented resource constraints and environmental questions persist, causing many to advocate a shift in policy that supports more green power development. While additional advances from conventional energy resources are to be expected, these advances will not likely succeed at resolving the issues of finite limits of resource availability, foreign dependence, and environmental constraints such as urban air pollution, habitat destruction, containment of radioactive wastes, and contribution to global warming. By contrast, green power is infinite, environmentally benign, and in most cases, domestically produced.

Not too long ago, most green power technologies were thought of as nothing more than an expensive sideshow. However, this notion is fast becoming a thing of the past. Many feel that the need to diversify is more urgent than ever. Global energy demand is expected to triple by mid-century, and critics of current energy policy say it's unreasonable to imagine fossil fuels would still be able to supply 80% of our energy. These two factors they contend will lead to increased prices for electricity. However, there's more to worry about than just supply and price. A concern also exists that global warming from heat-trapping carbon-dioxide, a by-product of fossil-fuel burning, could wreck havoc on the earth's climate. The stated solution to this problem is green power.

Another driver increasing worldwide green power production is the deregulation of electricity markets all over the world. Liberalizing electric markets have opened opportunities for competition within electricity generation. Utilities are "going green" as a way to set their service apart from the competition. Green pricing and green tag programs are giving consumers the opportunity to demonstrate that they are willing to pay the additional cost for environmentally conscious technologies. However, results to date have been, at most, a moderate success.

There are a number of promising green power technologies. BioPower is the generation of electricity using biomass -- organic plant matter such as trees, grasses, and agricultural crops. Biomass can be used as a solid fuel, or converted into liquid or gaseous forms for the production of electric power. Geothermal power plants generate electricity from deep wells drilled into underground reservoirs to tap steam and very hot water to drive turbines. The ocean can be used in two completely different ways to generate electricity with mechanical energy from the tides and waves and thermal energy from differences in water temperature at different depths. Photovoltaic (PV) systems convert light from the sun into electricity in solid-state semiconductor devices. Sunlight can also be concentrated to more efficiently generate electricity through PVs or to use the sun's heat to drive a turbine. Wind turbines uses the wind to spin blades attached to a turbine and are the major source of utility-scale green power.

While these technologies hold great promise, the cost to generate power from renewable sources remains, on average, more expensive than conventional sources. However, it is hoped that costs will come down to competitive levels as companies travel down the learning curve to maximize output, increase efficiency, and gain economies of scale. Many governments are funding research and development of green power to speed this hoped for reduction in cost along.

There appears to be great potential for the growth of green power in the future. Worldwide, renewable energy use is expected to increase by 53 percent between 1999 and 2020, or 2.1% per year, according to the U.S. Energy Information Administration (EIA). However, its current 9 percent share of total energy consumption is projected to drop slightly to 8 percent by 2020. Over this period, growth in renewable energy resources is expected to continue to be constrained by relatively moderate fossil fuel prices. In the developing world, particularly in countries of developing Asia, such as China, India, Malaysia, and Vietnam, much of the growth in renewable energy use is driven by the installation of large-scale hydroelectric power plants. In the industrialized world, non-hydroelectric renewable energy sources are projected to predominate, particularly wind power in Western Europe and biomass and geothermal power in the United States.

Many countries, including the U.S., got involved with green power in the 1970's as a result of the oil embargo by the Organization of the Petroleum Exporting Countries (OPEC). In 1978, President Carter signed into law the National Energy Act of 1978, a compendium of five bills that sought to decrease the Nation's dependence on foreign oil and increase domestic energy conservation and efficiency. One of these bills was the Public Utility Regulatory Policies Act of 1978 (PURPA). PURPA was the most significant section of the National Energy Act in fostering the development of facilities to generate electricity from green sources. PURPA opened the door to competition in the U.S. electricity supply market by requiring utilities to buy electricity from qualifying facilities (QFs). QFs were defined as non-utility facilities that produced electric power using cogeneration technology, or power plants no greater than 80 megawatts of capacity that use green power sources. PURPA is considered the primary contributor to the soaring amount of renewable energy supply in the U.S. in the 1980s. At that time, electricity costs were rising and demand for growth was high, which led to favorably priced, long-term contracts for renewable generation.

On the other side of the world, Europe is being driven to invest in green power mainly by the Kyoto Protocol. The European Union (EU) has agreed to reduce greenhouse gas emissions by 8% from 1990 levels by 2008-2012 to help curb global warming. In order to meet this goal, each European Member State has adopted its own green power targets. Australia and South America are also getting involved with green power production. South America has always relied on hydropower to generate electricity, but growing concerns over recent droughts and bad reputation South America has received due to the destruction of the rain forests have made their governments want to clean up their act. There has been a growing demand for green power in Australia. Around 60,000 customers across Australia have chosen green power products, including 2,500 businesses.

Most governmental support of green power has been driven first by energy security concerns (i.e., the oil crises of the 1970's) and then by environmental concerns (i.e., Kyoto). In response, most governments have set specific green power targets. In order to meet these targets, there are a variety of incentives for the production of green power used throughout the world. These incentives include price support mechanisms, financial incentives/subsidies, tax incentives, tax exemptions, guaranteed sale of electricity to the national grid, and green certificates. Some countries have also sought to reduce administrative and technical barriers such as planning rules and arrangements for access to electricity grids and have introduced targeted information campaigns aimed at developers and the public.

However, not all green power activities are spurred on by the government. Deregulation of the electricity industry is providing consumers with choices as to who their power supplier will be and the content of the power product. Ironically, as the ongoing wave of electric utility deregulation forces utilities to scramble for the lowest-cost power, some companies have found they can sell power at a higher economic cost if it has a low environmental cost. More and more utilities are starting green pricing programs, which offer green power to interested customers at a premium price. In other words, one kWh is suddenly different from another -- and this represents a sea of change for utilities which are used to treating kWh as all created equal.

Another program utilized by private industry to spur consumer interest in green power is green tag programs. Green Tags, which are also referred to as Green Certificates, Green Tickets, Renewable Energy Credits (RECs), or Tradable Renewable Certificates (TRCs), represent the environmental and social attributes of green power. Green tags offer an innovative strategy for giving consumers the opportunity to support green power, regardless of whether or not their local utility offers a renewable energy alternative. Utilities can continue selling customers their current mix of energy while customers support renewable energy on their own by purchasing green tags through a green tag marketer.

In the U.S., green tags are being driven by private industry. Europe approaches green tags from a slightly different perspective. Europeans see green tags as a way to integrate renewable energy in the wholesale market in order to fulfill the requirements of the Kyoto Protocol. Therefore, the European Union has instituted several projects to help them understand how best to incorporate green tags in their increasingly liberalized market. Also, a non-governmental group called the Renewable Energy Certificate System (RECS) has taken the lead in developing their own green tag marketing system that they hope others will join once they are convinced how workable it is. Plus, many countries are working on their own individual markets rather than waiting for the EU to develop a system. The ultimate challenge will be uniting these individual plans into one international market.

Introduction

Green power refers to power generation technologies that have a relatively low impact on the environment. Most, but not all renewable resources are considered "green." Generally accepted green power sources include biopower, geothermal power, ocean power, solar power, and wind power. Other technologies that might be considered green include hydropower and gas-fired power. Most environmentalists do not consider hydropower to be very "green" because although it is renewable and produces no emissions, it tends to have severe environmental effects on fish. In addition, many hydro projects involve creating a reservoir or dam thereby flooding significant acreage and changing water flows. Natural gas produces relatively few emissions, but is non-renewable and the drilling and transporting process are considered to cause significant environmental degradation.

In addition to these, fuel cells and stirling engines are sometimes considered green. But in and of themselves, they are simply generators. The level of emissions they produce is a factor of the fuel used in them and whether the fuel is renewable. Therefore, in keeping with general industry consensus, this report will only include bio, geothermal, ocean, solar, and wind power as green energy sources.

Green power sources are continuously and sustainably available in the environment. They are non-polluting, emission free, and their waste, if there is any, can also often be used as a fuel source.

Green power sources will become increasingly important as fossil fuel supplies dwindle. Some green power sources are at more advanced stages of development than others, for example biopower is already well established. And some sources are used more in certain countries than others due to local availability, for example the UK has a favorable location to develop wind power but is poorly located for solar.

There are four current drivers pushing green power into an expanded role in the generation of electric energy: 1) Global liberalizing trends, 2) Governmental response to environmental concerns, 3) Consumer response to environmental concerns, and 4) Competitiveness of technologies.

Global Liberalizing Trends

The deregulation of electricity markets is one of the primary drivers of increasing worldwide green power production. The EU has made membership contingent upon deregulation. Liberalizing electric markets have opened opportunities for competition within electricity generation. Competition provides a number of benefits to utilities for "going green." First, green power programs reduce pollution. According to the EPA, electric generation by conventional methods is the single largest source of industrial air pollution in the nation. As utilities come under increasing pressure to lower their impact on air quality and the climate, green power programs offer an opportunity to offset some of the adverse environmental effects of conventional power generation. Second, investing in green power diversifies the energy mix, reducing dependence on fossil fuels (and their attendant price fluctuations) and providing for the long-term stability of the economy. Third, green power projects provide a local economic boost. Rather than sending dollars out of the community to pay for imported fuel, customers spend locally to build and maintain generating systems that are fueled for free. Finally, involvement in green power enhances corporate image. As ratepayers become more concerned about the environment, a utility's involvement in green power can serve to increase customer satisfaction with the utility and enhance the value utility's brand name.

Governmental Response to Environmental Factors

The threat of global warming has significantly increased the attention that governments are paying to the environment. In December 1997, representatives from more than 160 countries met in Kyoto, Japan, to negotiate binding limits on greenhouse gas emissions for developed nations. The resulting Kyoto Protocol established emissions targets for each of the participating developed countries relative to their 1990 emissions levels. The targets range from an 8% reduction for the EU (or its individual member states) to a 10% increase allowed for Iceland. China and India are not considered "developed" nations under Kyoto and are exempted. The U.S. is supposed to have a 7% reduction from 1990 levels.

The Kyoto Protocol requires 38 industrial countries[1] to reduce their emissions of greenhouse gases an average of 5.2% below 1990 levels in the 2008-2012 time frame. Talks on the protocol at the United Nations Framework Convention on Climate Change (UNFCCC) were completed December 11, 1997 and the treaty was opened for signature March 16, 1998 at the UN headquarters in New York. Fifty-five countries, representing 55% of the emissions of industrialized countries, must ratify Kyoto for it to enter into force and become legally binding. A conference on climate change in The Hague, Netherlands at the end of November 2000 failed to reach an agreement on ratifying the Kyoto Protocol. Despite this set-back, the European Union and a number of other countries have set their own targets for green power to reduce emissions.

Consumer Response to Environmental Factors

Deregulation of the electric industry is providing consumers with choices on who their power supplier will be and giving them control over the content of the power they buy. As a response to growing concern over global warming and pollution, consumers have expressed a willingness to pay a premium for green power products.[2] Green power pricing and green tag programs have emerged largely in response to this consumer demand. In a green power pricing program, the power provider gives customers the option to buy electricity generated from environmentally friendlier sources. Usually this option costs a little more because, on average, it is still more expensive to generate environmentally friendly power than traditional power using coal, natural gas, and nuclear. Where there is a cost premium, it shows up on the customer's monthly electricity bill. In a green tag program, customers purchase green tags which correspond to an amount of green power that was generated and sold into the market where it originated. They represent the real savings in carbon dioxide (CO_2) and other pollutants that occur when green power replaces the burning of fossil fuels.

Competitiveness of Technologies

The cost to generate power from renewable sources remains, on average, more expensive than conventional sources. However, in certain circumstances green power generation is cost competitive. Co-firing biomass and large-scale wind turbines (with average wind speeds) are examples. By way of comparison, the following chart illustrates the leveled cost per kilowatt-hour of green power technologies. The range in price depends on the type of technology used.

---

[1] The 38 countries include Australia, Bulgaria, Canada, Croatia, Czech Republic, Estonia, European Union (15), Hungary, Iceland, Japan, Latvia, Liechtenstein, Lithuania, Monaco, New Zealand, Norway, Poland, Romania, Russian Federation, Slovakia, Slovenia, Switzerland, Ukraine, United States.

[2] B. Farhar, *Willingness to Pay for Electricity from Renewable Resources: A Review of Utility Market Research*. NREL, 1999.

For example, a direct-fired biomass plant is more expensive than a co-fired biomass plant. The size of the plant is an important factor when considering price per kilowatt-hour. As a general rule, the larger the plant the less expensive.

Table 1: Cost Per Kilowatt-Hour Of Green Power Technologies

Technology	Cost per kWh
BioPower Plant	5-9¢
Geothermal Plant	5-8¢
Solar Concentrating Power Plant	9-12¢
Wind Power Plant	3-5¢

Source: US Department Of Energy

While green power technologies are more expensive than other generation alternatives, most governments have put into place subsidy programs, which improve their cost-competitiveness. In addition, many governments have developed funding for research and development to lower the cost of green power technologies.

Green Power Technologies

Green Power technologies are commonly defined by the fuel the respective technology uses in order to create electricity. For example, solar generation uses sunlight as the fuel; wind turbines use wind, and so forth. We have classified renewable energy into the following five categories: BioPower, Geothermal, Ocean, Solar and Wind. This section will discuss these technologies in detail. It will also discuss stirling engine technology in the context of its use with concentrating solar power, and fuel cell technology, which has the potential to be a green power in the future.

BioPower

BioPower is the generation of electricity using "biomass." Biomass is organic plant matter such as trees, grasses, and agricultural crops. Biomass can be used as a solid fuel, or converted into liquid or gaseous forms, for the production of electric power.

Biomass can be converted into electricity (or heat) in one of several processes. The majority of BioPower is generated using a steam cycle: biomass material is converted to steam in a boiler; the steam then turns a turbine, which is connected to a generator. Biomass can also be used in conjunction with coal to produce power. Cofiring biomass with coal in existing boilers is the nearest term low-cost option for using biomass. In the cofiring process, biomass is introduced as a supplementary energy source in high efficiency boilers.

Solid biomass can also be converted into a fuel gas. The fuel gas can then be used in a piston-driven engine, high-efficiency gas turbine generator or a fuel cell. Biomass gas can also be integrated into industrial manufacturing plants for power, heat and cooling needs. Residues are the most economical biomass fuels for generating electricity. These are the organic byproducts of food, fiber, and forest production. Examples include sawdust, rice husks, and bagasse (the residue remaining after juice has been extracted from sugar cane). Used shipping pallets and yard trimmings are low cost sources of biomass and are common near population and manufacturing centers.

Wood is the most commonly used biomass fuel for heat and power. The most economic sources of wood fuels are usually wood residues from manufacturers, discarded wood products diverted from landfills, and non-hazardous wood debris from construction and demolition activities. Use of these materials for electricity generation can recoup the energy value in the material while avoiding landfill disposal. In the future, fast-growing energy crops may become the biomass fuel of choice. These energy crops will be genetically tailored plants designed to be fast-growing, drought resistant, and readily harvested, allowing them to become a competitively-priced fuel.

The key to successful biomass power development is to use the resource efficiently in modern conversion systems that maximize the energy produced and minimize the byproducts of conversion processes. Until the 20th century, using biomass to generate heat or to drive steam engines was the most common way to produce energy. However, historical methods of burning wood, field residues, or wood wastes and byproducts have tended to be less efficient than modern conversion systems currently available and in development. In modern times, the combination of improved technological efficiencies, scientific advances, increased environmental awareness, and environmental protection regulations have turned biomass conversion into a cleaner, more efficient process.

BioPower technologies convert renewable biomass fuels to heat and electricity using equipment similar to that used with fossil fuels. A key attribute of biomass is its availability upon demand – the energy is stored within the biomass until it is needed. Other forms of renewable energy are dependent on variable environmental conditions such as wind speed or sunlight intensity. There are three primary classes of BioPower systems used for green power: direct-fired, co-fired, and gasification.

Direct-Fired: Most of today's BioPower plants are direct-fired systems that are similar to most fossil-fuel fired power plants. The biomass fuel is burned in a boiler to produce high-pressure steam. This steam is introduced into a steam turbine, where it flows over a series of aerodynamic turbine blades, causing the turbine to rotate. The turbine is connected to an electric generator, so as the steam flow causes the turbine to rotate, the electric generator turns and electricity is produced.

While steam generation technology is very dependable and proven, its efficiency is limited. Biomass power boilers are typically in the 20-50 MW range, compared to coal-fired plants in the 100-1500 MW range. The small capacity plants tend to be lower in efficiency because of economic trade-offs; efficiency-enhancing equipment cannot pay for itself in small plants. Although techniques exist to push biomass steam generation efficiency over 40%, actual plant efficiencies are in the low 20% range.

Co-Firing: Co-Firing involves substituting biomass for a portion of coal in an existing power plant furnace. It is the most economic near-term option for introducing new biomass power generation. Because much of the existing power plant equipment can be used without major modifications, co-firing is far less expensive than building a new BioPower plant. Compared to the coal it replaces, biomass reduces sulfur dioxide, nitrogen oxides and other air emissions. After "tuning" the boiler for peak performance, there is little or no loss in efficiency from adding biomass. This allows the energy in biomass to be converted to electricity with the high efficiency (in the 33-37% range) of a modern coal-fired power plant.

Boiler technologies where co-firing has been practiced, tested, or evaluated, include wall fired and tangentially designed pulverized coal (PC) boilers, coal-fired cyclone boilers, fluidized-bed boilers, and spreader stokers. The current coal-fired power generating system represents a direct system for carbon mitigation by substituting biomass-based renewable carbon for fossil carbon. Extensive research and development, field validation tests and trials have shown that biomass energy can be substituted for up to 15% of the total energy input by modifying little more than the burner and feed intake systems. Since large-scale power boilers in the U.S.' current 310 GW capacity fleet range from 100 MW to 1.3 GW, the biomass potential in a single boiler ranges from 15 MW to 150 MW.

BioPower Gasifiers: BioPower Gasifiers operate by heating biomass in an environment where the solid biomass breaks down to form a flammable gas. This offers advantages over directly burning the biomass. The biogas can be cleaned and filtered to remove problem chemical compounds. The gas can be used in more efficient power generation systems called combined-cycles, which combine gas turbines and steam turbines to produce electricity. The efficiency of these systems can reach 60%. Some benefits of gasification include:

- Gasification is an additional process step that not only produces a more easily used fuel form for power generation equipment, but provides the means to remove fuel components that are problems for downstream power generation systems.

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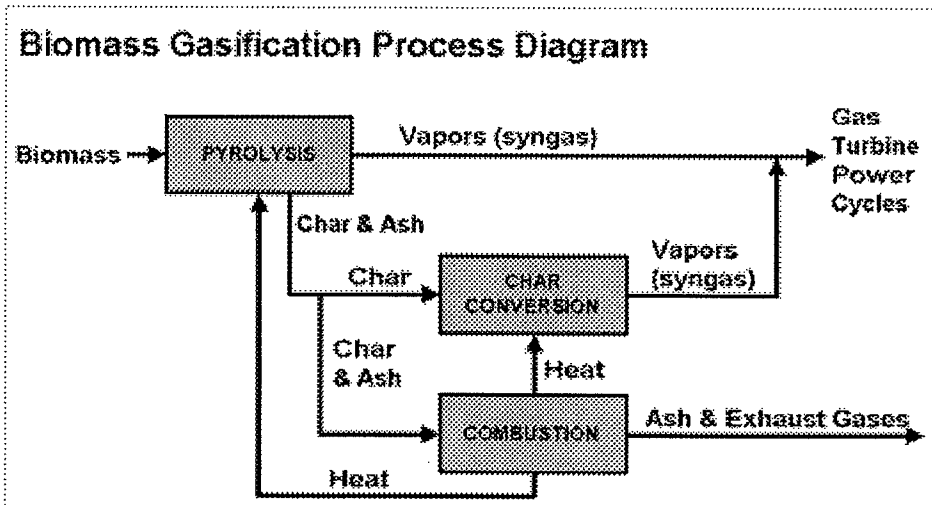
- Gasification gives biomass the flexibility to fuel a wide range of power systems: gas turbines, fuel cells, and reciprocating engines and microturbines.
- A wide variety of biomass materials can be gasified -- many of which would be difficult or impossible to burn otherwise.
- Gasification offers one means of processing waste fuels -- many of which can be problematic. Gasification and conversion to energy is an outstanding alternative to expensive and environmentally unfavorable disposal in landfills.
- It is easier to distribute and control a gaseous fuel.
- Gasification coupled with advanced conversion cycles reduces air emissions per kWh of electricity produced.
- A gaseous fuel allows biomass to leverage the high efficiency power generation capabilities of combined gas and steam cycle plants and fuel cells.

Figure 1: Biomass Gasification Process



Source: EREN

Modular Systems: Small, modular BioPower systems have potential to be used in distributed generation markets. These applications involve power generation attached to the transmission and distribution grid near where the consumer uses electricity. Some may be owned by the consumers and connected to the power gird on the customer side of the electric meter.

Modular systems also have the potential to bring electricity to more than 2.5 billion people who currently live without electricity. Most of these people live in regions where large amounts of biomass is available for fuel. Small systems, with rated capacities of less than 5 MW could provide power at the village level.

Successful commercialization of small BioPower systems completes the development of a BioPower industry covering a range of power applications, including small systems for village power or distributed applications; combined heat and power systems for industrial applications; and cofiring, gasification, and advanced combustion for utility-scale power generation.

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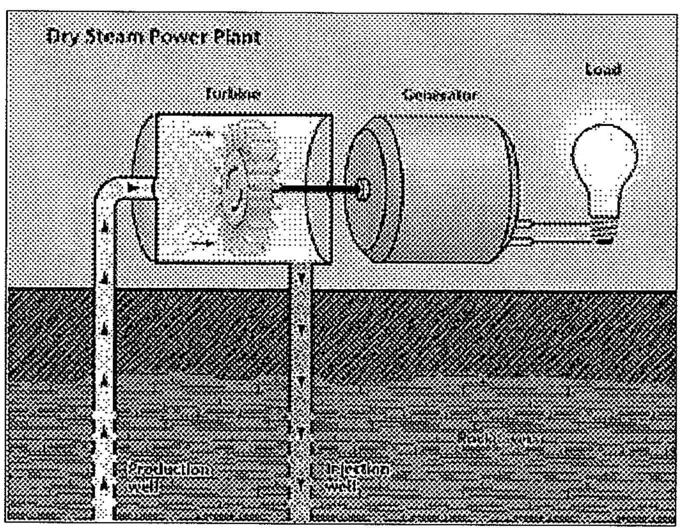
Geothermal

Geothermal power plants generate electricity from geothermal reservoirs. Mile-or-more-deep wells can be drilled into underground reservoirs to tap steam and very hot water that drive turbines to run electricity generators. Currently, there are three types of geothermal power plants operating -- Dry Steam, Flash Steam, and Binary-Cycle. The type of plant built at a given site depends on the type and temperature of the geothermal resource. Direct steam plants are used at sites where the geothermal resource consists of high-quality steam. Flash plants are used at sites that produce high-temperature water. Binary-cycle plants convert lower temperature geothermal waters to electricity by first routing the fluid through a closed-loop heat exchanger, where it heats a hydrocarbon working fluid. The hot brine converts the working fluid, which has a very low boiling point, to its gaseous phase; the gas is then used to turn the turbine.

The three technologies discussed below use only a tiny fraction of the total geothermal resource. Several miles everywhere beneath Earth's surface is hot, dry rock being heated by the molten magma directly below it. Technology is being developed to drill into this rock, inject cold water down one well, circulate it through the hot, fractured rock, and draw off the heated water from another well. In the future, the direct heat recovery from magma may be possible.

Dry Steam Power Plants: Steam plants use hydrothermal fluids that are primarily steam. The steam goes directly to a turbine, which drives a generator that produces electricity. The steam eliminates the need to burn fossil fuels to run the turbine. (Also eliminating the need to transport and store fuels) This is the oldest type of geothermal power plant. It was first used at Lardarello in Italy in 1904, and is still very effective. Steam technology is used today at The Geysers in northern California, the world's largest single source of geothermal power. These plants emit only excess steam and very minor amounts of gases.

Figure 2: Dry Steam Geothermal Plant



Source: EREN

Flash Steam Power Plants: Hydrothermal fluids above 400°F (200°C) can be used in flash plants to make electricity. Fluid is sprayed into a tank held at a much lower pressure than the fluid, causing some of the fluid to rapidly vaporize, or "flash," to steam. The steam then drives a

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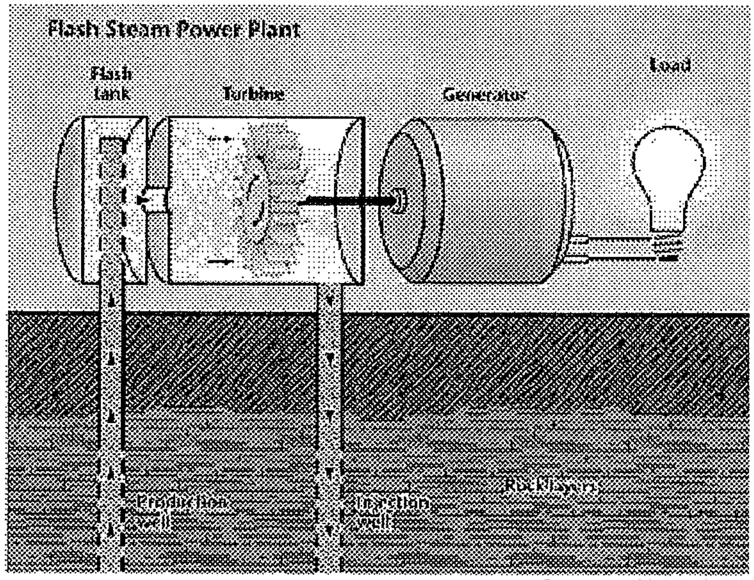
turbine, which drives a generator. If any liquid remains in the tank, it can be flashed again in a second tank to extract even more energy. Only excess steam and trace gases are emitted.

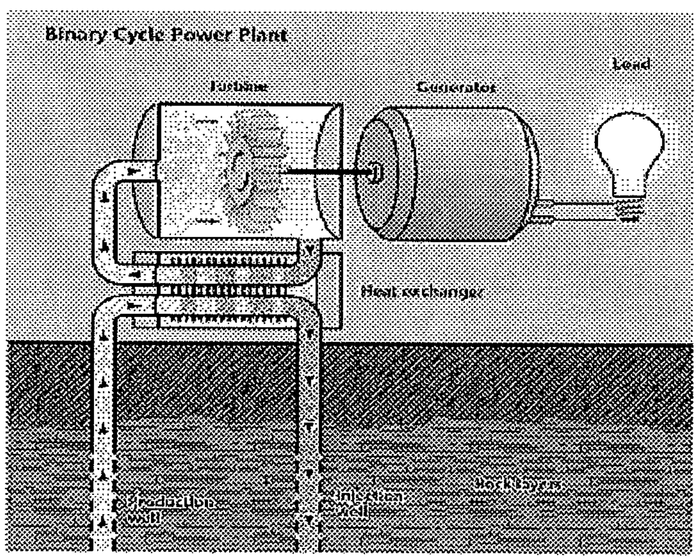
Figure 3: Flash Steam Geothermal Plant



Source: EREN

Binary-Cycle Power Plants: Most geothermal areas contain moderate-temperature water (below 400°F). Energy is extracted from these fluids in binary-cycle power plants. Hot geothermal fluid and a secondary (hence, "binary") fluid with a much lower boiling point than water pass through a heat exchanger. Heat from the geothermal fluid causes the secondary fluid to flash to steam, which then drives the turbines. Because this is a closed-loop system, virtually nothing is emitted to the atmosphere. Most geothermal power plants in the future will be binary-cycle plants.

Figure 4: Binary Cycle Geothermal Plant



Source: EREN

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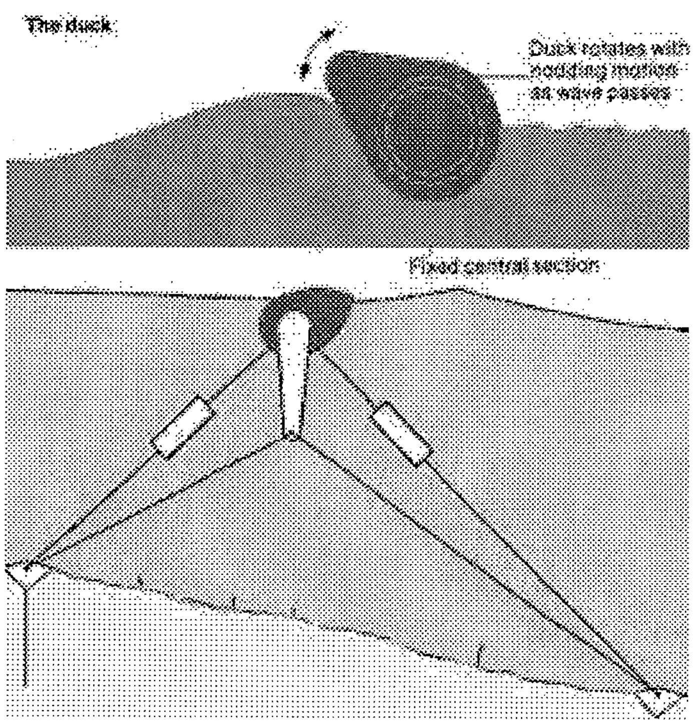
Ocean

The ocean contains two types of energy: mechanical energy and thermal energy. There are three types of ocean energy technologies: Wave Energy, Tidal Energy, and Ocean Thermal Energy Conversion Systems (OTEC). Ocean mechanical energy is quite different from ocean thermal energy. Tides are driven primarily by the gravitational pull of the moon, and waves are driven primarily by the winds. A barrage (dam) is typically used to convert tidal energy into electricity by forcing the water through turbines, activating a generator. The tidal current can also be used to directly drive a turbine like an underwater windmill. For wave energy conversion, there are three basic systems: float systems that drive hydraulic pumps, oscillating water column systems that use the waves to compress air within a container, and channel systems that funnel the waves into reservoirs. The mechanical power created from these systems either directly activates a generator or transfers to a working fluid, water, or air, which then drives a turbine/generator.

Wave Energy

Harnessing the power in ocean waves is one way to extract energy from the seas. Wave power devices extract energy directly from surface waves or from pressure fluctuations below the surface. Renewable energy analysts believe there is enough energy in the ocean waves to provide up to 2 terawatts of electricity. However, wave power can't be harnessed everywhere. Wave power rich areas of the world include the western coast of Scotland, northern Canada, southern Africa, Australia, and the northeastern and northwestern coasts of the U.S. In favorable locations, wave energy density can average 65 MW per mile of coastline.

Figure 5: Salter Duck



Source: Fujita Research

The Salter Duck and other floating wave energy devices generate electricity through the harmonic motion of the floating part of the device. In these systems, the devices rise and fall

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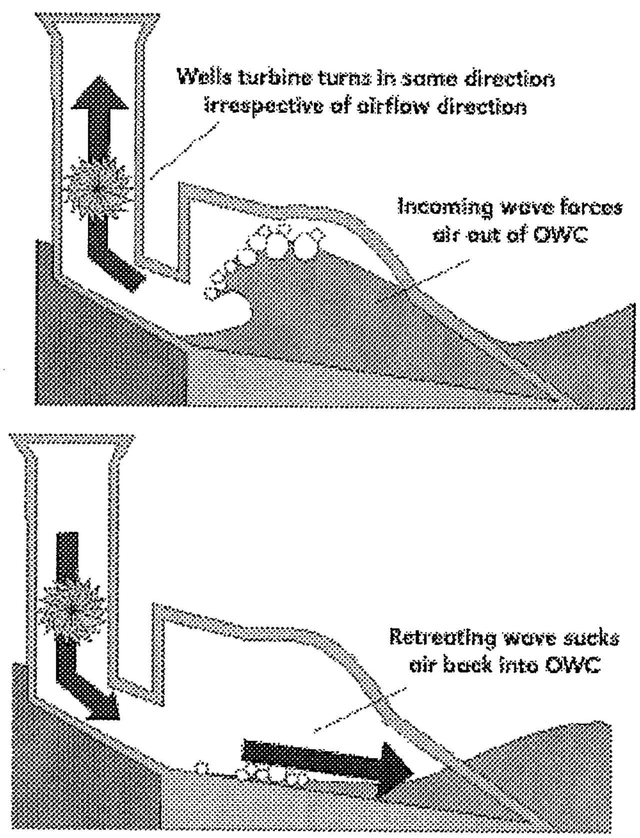
according to the motion of the wave and electricity is generated through their motion. As they bob up and down on the water, a pump is driven and electricity is generated. The Salter Duck is able to produce energy extremely efficiently, however its development was stalled during the 1980s due to a miscalculation in the cost of energy production by a factor of 10 and it has only been in recent years when the technology was reassessed and the error identified.

One company is developing buoys that create electricity when moved by an outside force such as water. The buoys are submerged more than a meter below the water's surface. A cylinder inside the buoy moves around a piston-like structure as the buoy bobs with the rise and fall of the waves. That movement drives a generator on the ocean floor, producing electricity, which is sent to the shore along an underwater cable. Computer chips monitor the system's performance and will disconnect the system if extra large waves threaten to disrupt it, as well as reconnect the system once waves return to normal.

Onshore wave power systems are built along shorelines to extract energy from breaking waves. Oscillating Water Columns are generally onshore systems.

Figure 6: Oscillating Water Column



Source: Fujita Research

The system consists of a partially submerged concrete or steel structure that has an opening to the sea below the waterline. It encloses a column of air above a column of water. As a wave enters the column, it forces the air in the column up the closed column past a turbine, and increases the pressure within the column. As the wave retreats, the air is drawn back past the

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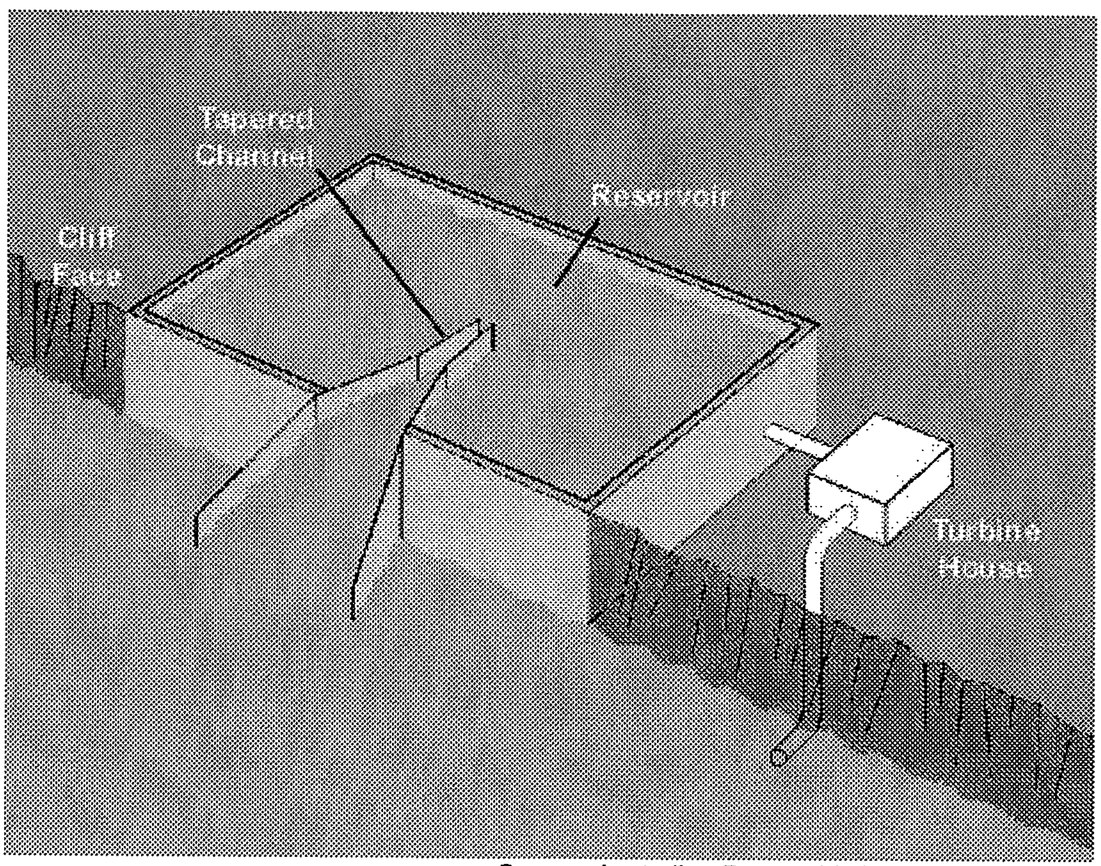
turbine due to the reduced air pressure on the ocean side of turbine. Much international research is focused on developing oscillating water columns, which require less stringent siting conditions.

Several oscillating water column devices have been built worldwide. India has an oscillating water column wave energy plant under testing in Vizhinjam, Kerala. A 500 kW oscillating water column has been built on the island of Pico in the Azores. It is expected to generate enough electricity to power several hundred island homes. The world's first commercial wave power plant, the Limpit, was commissioned on the rocky west coast of the Scottish island Islay. The Limpit generates 500 kW.

Another way to capture the energy of offshore waves is through specially designed seagoing vessels. These floating platforms create electricity by funneling waves through internal turbines and then back into the sea. Basically, these vessels are floating oscillating water column devices. The Japan Marine Technology Center has developed a prototype wave power vessel that carries three air turbine generator units. The vessel is called the Mighty Whale and it's designed to be anchored to the seabed, but can be remotely controlled from shore. The Mighty Whale can be used to generate up to 110 kWh.

Tapered channel systems (TAPCHAN), consist of a tapered channel, which feeds into a reservoir constructed on cliffs above sea level.

Figure 7: Tapered Channel System



Source: Australian Renewable Energy Website

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The narrowing of the channel causes the waves to increase their amplitude (wave height) as they move toward the cliff face which eventually spills over the walls of the channel and into the reservoir and the stored water is then fed through a turbine. The site requirements for TAPCHAN systems are daunting -- low tidal ranges and cliff-like shoreline characteristics – so no TAPCHAN systems have yet to be constructed for commercial purposes. However, a demonstration system was built in Toftesfallen, Norway, during the 1980s. It functioned successfully until it was damaged during maintenance operations.

The concept of TAPCHAN is an adaptation of traditional hydroelectric power production: collect the water, store the water, and run it past a turbine on its way out. With very few moving parts, all contained within the generation system, TAPCHAN systems have low maintenance costs and a greater reliability. TAPCHAN systems also overcome the issue of power on demand, as the reservoir is able to store the energy until it is required. Unfortunately, TAPCHAN systems are not suitable for all coastal regions. Suitable locations for TAPCHAN systems must have consistent waves, with a good average wave energy and a tidal range of less than 1m, suitable coastal features including deep water near to shore and a suitable location for a reservoir.

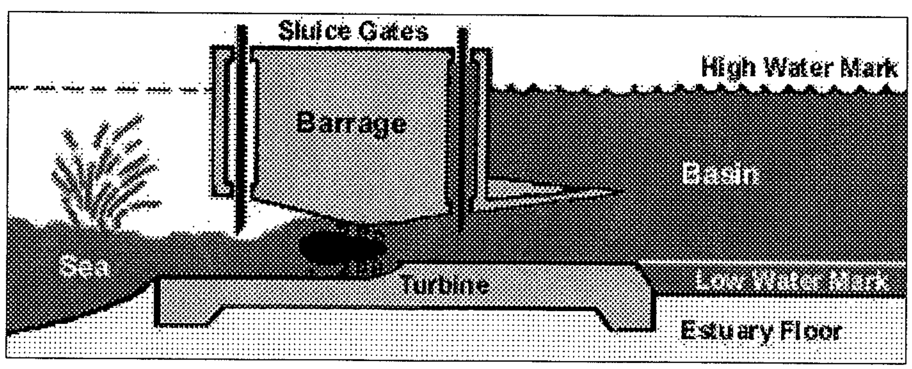
Tidal Energy

Tidal energy takes advantage of the natural rise and fall of coastal tidal waters caused primarily by the gravitational effect of the Moon and, to a lesser extent the Sun, on the world's oceans. The Earth's rotation is also a factor in the production of tides. All coastal areas consistently experience two high and two low tides over a period of slightly greater than 24 hours. But for those tidal differences to be harnessed into electricity, the difference between high and low tides must be at least five meters, or more than 16 feet.

Tide mills were in use on the coasts of Spain, France and the UK before 1100AD and in tidal estuaries (e.g. the Schelde river in Belgium) around 1800AD. They remained in common use for many centuries, but were gradually replaced by cheaper and more convenient methods of power generation. A tide mill consisted of a pond filled through a sluice during the flood tide and emptied on the ebb tide via an undershot waterwheel.

The modern version of a tide mill is a semi-permeable barrage built across an estuary, allowing flood waters to fill an impounded basin via a series of sluices.

Figure 8: Tide Mill

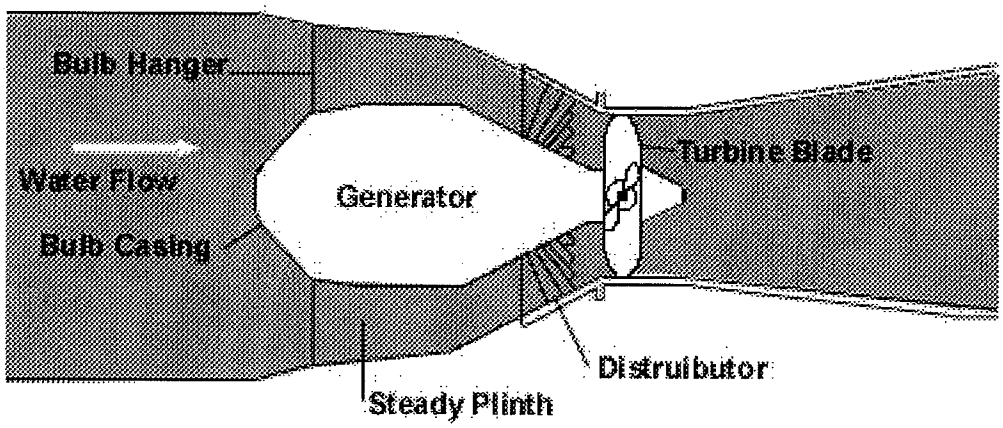


Source: The Australian Renewable Energy Website

At high water the sluice gates are closed, creating a head of water on the ebb tide. Electricity is generated by releasing the water through a series of conventional bulb turbines. In future schemes the energy yield would be enhanced by pumping water into the estuary on the flood tide ('flood pumping'), thereby increasing the volume of water released through the turbines on the ebb tide.

However, several other turbine configurations are possible. For example, the La Rance tidal plant near St. Malo on the Brittany coast in France uses a bulb turbine as in figure 9. The La Rance tidal plant is a 240 MW demonstration plant that was built on the Rance estuary during the 1960's and has now completed 30 years of successful operation. The only problem they've encountered with this type of tidal plant is that since water flows around the turbine, access for maintenance is difficult because the water must be prevented from flowing past the turbine.

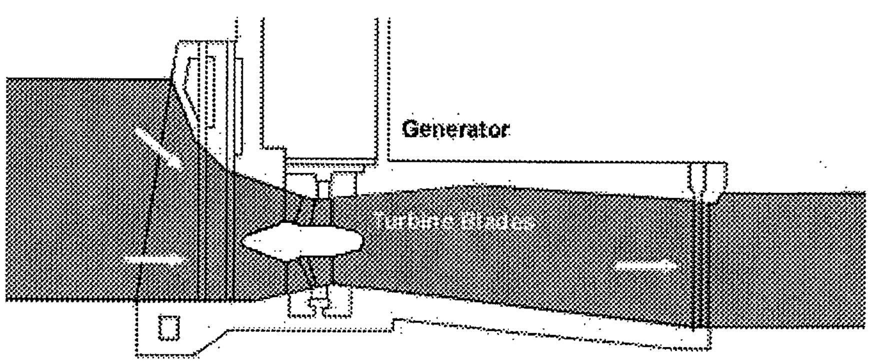
Figure 9: Bulb Turbine with Tide Stream Generator



Source: The Australian Renewable Energy Website

Another configuration is known as rim turbines (figure 10), such as the Straflo turbine used at Annapolis Royal in Nova Scotia. Rim turbines are easier to maintain as the generator is mounted in the barrage, at right angles to the turbine blades. Unfortunately, it is difficult to regulate the performance of these turbines and it is unsuitable for use in pumping. Tubular turbines as in figure 11 have been proposed for use in the Severn tidal project in the UK. In this configuration, the blades are connected to a long shaft and situated at an angle so that the generator is sitting on top of the barrage.

Figure 10: Rim Turbine



Source: The Australian Renewable Energy Website

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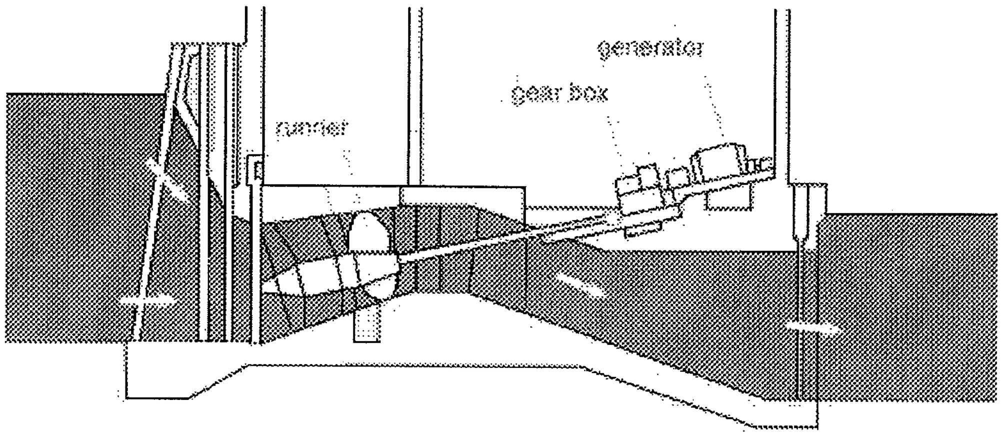
Figure 11: Tubular Turbine



Source: The Australian Renewable Energy Website

Another technology to harness tidal energy is the tidal fence. Tidal fences look like giant turnstiles. They can reach across channels between small islands or across straits between the mainland and an island. The turnstiles spin via tidal currents typical of coastal waters. Some of these currents run at 5 to 8 knots (5.6 to 9 miles per hour) and generate as much energy as winds of much higher velocity. Because seawater has a much higher density than air, ocean currents carry significantly more energy than air currents or wind. There are no large-scale commercial tidal fences currently in operation; however, there are plans to construct a fence across the Dalupiri Passage between the islands of Dalupiri and Samar in the Philippines.

Finally, tidal turbines are a ocean power technology that looks much like wind turbines. They are arrayed underwater in rows, as in some wind farms. The turbines function best where coastal currents run at between 3.6 and 4.9 knots (4 and 5.5 mph). In currents of that speed, a 15 meter diameter tidal turbine can generate as much energy as a 60-meter diameter wind turbine. Ideal locations for tidal turbine farms are close to shore in water depths of 20 to 30 meters. Currently, there are no operational tidal turbine farms.

Ocean Thermal Energy Conversion Systems (OTEC)

OTEC utilizes the temperature difference between the warm surface sea water and cold deep ocean water to generate electricity. Commercial OTEC plants must be located in an environment that is stable enough for efficient system operation. The temperature of the warm surface seawater must differ about 20°C (36°F) from that of the cold deep water that is no more than about 1000 meters (3280 feet) below the surface. The natural ocean thermal gradient necessary for OTEC operation is generally found between latitudes 20°N and 20°S. Within this tropical zone are portions of two industrial nations -- the U.S. and Australia -- as well as 29 territories and 66 developing nations. Of all these possible sites, tropical islands with growing power requirements and a dependence on expensive imported oil are the most likely areas for OTEC development.

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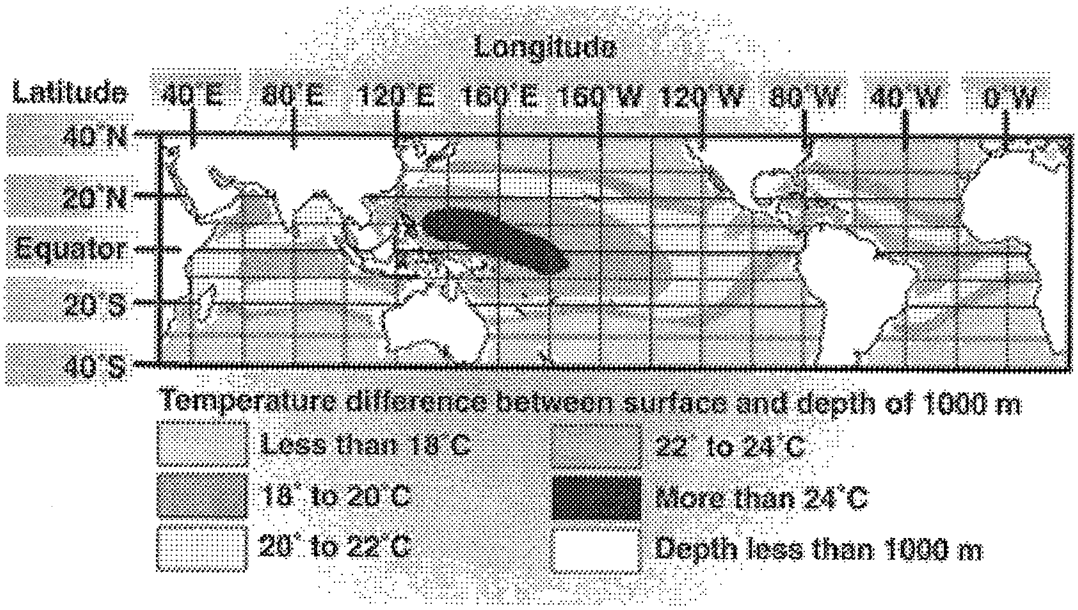
Figure 12: Ocean Thermal Differences



Source: EREN

Although the theoretical efficiency of OTEC is small (~2%), there are vast quantities of sea water available for use in power generation. It has been estimated that there could be as much as 10^7 MW of power available worldwide. There are three types of OTEC systems: closed-cycle, open-cycle, and hybrid. Closed-cycle systems use the ocean's warm surface water to vaporize a working fluid, which has a low-boiling point, such as ammonia. The vapor expands and turns a turbine. The turbine then activates a generator to produce electricity. Open-cycle systems actually boil the seawater by operating at low pressures. This produces steam that passes through a turbine/generator. And hybrid systems combine both closed-cycle and open-cycle systems.

Closed-Cycle OTEC: The original concept used a working fluid with a low boiling point, such as ammonia, which is vaporized using the heat extracted from the warm surface water. The heated working fluid is used to turn a turbine to produce electricity. Cold, deep-sea water is used to condense the working fluid in a second heat exchanger prior to being re-circulated to the first heat exchanger.

In 1979, a closed-cycle demonstration project called the Mini-OTEC (developed by the Natural Energy Laboratory of Hawaii) was commissioned and successfully generated net power. The plant was mounted on a converted U.S. Navy barge moored approximately 2 kilometers off Keahole Point. The plant used a cold-water pipe to produce 52 kW of gross power and 15 kW net power. Some significant problems, including the selection of metals in the heat exchanger, have had a strong influence on the economics using closed-cycle OTEC. In 1981, Japan demonstrated a shore-based, 100-kWe closed-cycle plant in the Republic of Nauru in the Pacific Ocean. This plant employed cold-water pipe laid on the sea bed to a depth of 580 meters. Freon was the working fluid, and a titanium shell-and-tube heat exchanger was used. The plant surpassed engineering expectations by producing 31.5 kW of net power during continuous operating tests.

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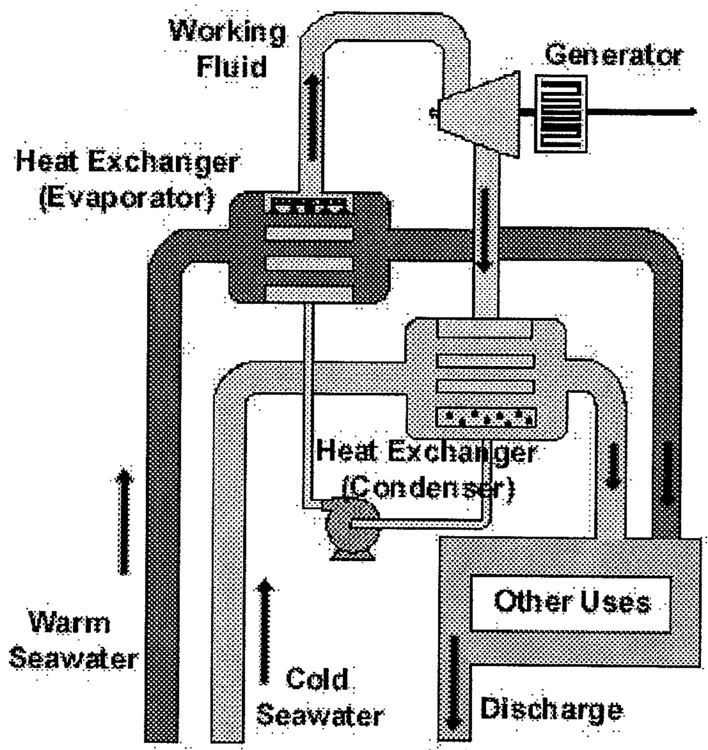
Figure 13: Closed-Cycle OTEC System



Source: EREN

In May 1993, an open-cycle OTEC plant at Keahole Point, Hawaii, produced 50,000 watts of electricity during a net power-producing experiment. This broke the record of 40,000 watts set by a Japanese system in 1982. Today, scientists are developing new, cost-effective, state-of-the-art turbines for open-cycle OTEC systems.

Open-Cycle OTEC: The first operational OTEC used warm surface water as the working fluid, instead of the low boiling point fluid used in the closed-cycle OTEC. In open-cycle OTEC systems, the seawater is evaporated under a partial vacuum, creating low-pressure steam, which can be used to drive a turbine. The steam is then condensed either by a second heat exchanger, as in the closed cycle, or by mixing with the deep cold water.

The Natural Energy Laboratory of Hawaii commenced initial research in this area in 1983 and resulted in the construction and operation of a 210kW open-cycle system from 1992 to 1998. This plant generated the largest amount of net energy from any OTEC system and demonstrated that fresh water could be extracted successfully from the open cycle system. Following the completion of the testing the plant was demolished in January 1999.